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OPERATION OF BRIQUETTING ROLLER PRESSES WITH AN ASYMMETRICAL COMPACTION UNIT

Key words: briquetting, roll press, asymmetrical compaction unit.

Abstract: The key issue in the briquetting process in a roll press is to properly customise the working surface. The conventional symmetrical compaction units employed in roller presses are often unsuitable for the consolidation of materials that show quasi-plastic properties or those which show significant elastic deformation after the pressure is removed. This is caused by the fact that ready-made briquettes tend to remain in moulding cavities or crack along the parting plane. This problem can be solved by using asymmetrical compaction units. They make it possible to expand the range of fine-grained materials, especially those which are hardly consolidable in a roll press and which can be used to make briquettes with satisfactory quality indexes. This article outlines the basics of the operation of roller presses equipped with asymmetrical compaction units and their current evolution.

Eksploatacja brykieciarek walcowych z niesymetrycznym układem zagęszczania

Słowa kluczowe: brykietowanie, prasa walcowa, niesymetryczny układ zagęszczania.

Streszczenie: W procesie brykietowania w prasie walcowej kluczowym jest odpowiedni dobór powierzchni roboczej. Klasyczne symetryczne układy zagęszczania stosowane w prasach walcowych często nie nadają się do scalania materiałów wykazujących cechy ciała quasi-plastycznego lub tych, które po ustąpieniu nacisku cechuje duże odkształcenie powrotne. Powodem tego jest to, że wytworzone brykiety mają tendencje do pozostawania we wgłębieniach formujących lub pękają w płaszczyźnie podziału. Rozwiązaniem tego problemu jest zastosowanie niesymetrycznych układów zagęszczania. Dzięki nim można rozszerzyć ilość materiałów drobnoziarnistych w szczególności tych o małej podatności na scalanie w prasie walcowej, z których można otrzymać brykiety o zadowalających wskaźnikach jakościowych. W niniejszym artykule nakreślono podstawy eksploatacji pras walcowych wyposażonych w układy niesymetryczne oraz ich obecną ewolucję.

Introduction

Pressurised agglomeration carried out in roller presses is presently a key process employed in the heavy [1–5], chemical [6–8], pharmaceutical [9–11] and power [12–14] industries. The major advantages of this type of machines include their constant operability with relatively low demand for energy and a longer life span of moulding components as compared to other briquetting machines (e.g., screw or stamping ones) or pressurised granulators [15–17]. This is why this process is in constant development [18]. The current research activities mainly aim at determining process and geometrical parameters of the machine in order to enable the consolidation of hardly briquettable materials in the roll press. The basis for this issue includes, among others, a proper choice of the feed supply system [19] and the ring moulding surface [20]. They determine the course and the effects of the loose material consolidation process [15, 21]. In most cases, the working surfaces provided on both rings to mould briquettes at a given moment are a mirror reflection of each other. In the case of hardly briquettable materials, they are preferably differentiated, that is, an asymmetrical compaction unit is preferably employed [20, 22]. The purpose of this study is to analyse the current state of the knowledge in the field of design and operation of briquetting machines equipped with asymmetrical compaction units.

1. Basics of Operation of Briquetting Roller Presses Equipped with an Asymmetrical Compaction Unit

The briquetting process in roller presses in asymmetrical systems has been developed since the 1980s. It was related to inventing a more economic method for the briquetting of lignite [21]. The then used agglomeration of that fuel in stamp presses showed high energy demand per end product unit coefficient; moreover, the idle movement which occurred in operation significantly reduced their output. The first attempts to briquette lignite in roller presses were unsuccessful. When the conventional symmetrical compaction unit was used, the ready-formed drop-shaped briquettes became delaminated within the parting plane (Fig. 1).

Fig. 1. View of a briquette consolidated in a roll press with a symmetrical compaction unit and delaminated along the parting plane

This problem was successfully solved by using an asymmetrical compaction unit. The essential property of this system is that the moulding components of the briquetting machine have circumferential grooves and notches alternately formed on the working surface (Fig. 6). The rings are arranged on the rollers in such a way that the grooves and the notches are positioned against each other, forming a split mould. This prevents the briquettes from getting split in half along the parting plane after they leave the moulding cavities. The research has shown that the maximum unit pressure value registered while briquetting material in an asymmetrical compaction unit occurs in the central part of the notch and in the corresponding zone of the circumferential groove surface. The unit pressure differentiation that was observed was not as high as it was in the case of a symmetrical system (Fig. 2) [21]. The research also proved that the asymmetrical compaction units offer a smaller gradient of deformations than the symmetrical systems (Fig. 3) [23, 24]. This shows that the briquettes are moulded in more preferable conditions, which may give them higher mechanical strength.

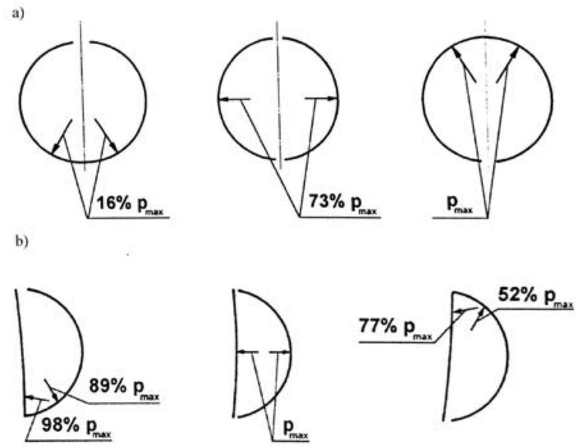

Fig. 2. Unit pressure value distribution during the briquetting process in a roller press [21]: a) symmetrical compaction unit, b) asymmetrical compaction unit

Positive results of experiments have contributed to the designing of industrial presses equipped with an asymmetrical system. This resulted in focusing the research on the need to verify whether a roll press can consolidate other raw materials that were not briquettable in symmetrical systems. Over the years, technologies have been developed to briquette several dozens of materials in roller presses equipped with asymmetrical systems. These include the following: metallurgical industry waste, chemical industry waste, fuels of different composition and origin, municipal waste and other, mainly inorganic, materials [11, 12, 15, 18, 25, 26]. The experiences gained while consolidating these materials in asymmetrical compaction units have allowed us to define the purpose of this type of solutions. They have been qualified mainly for the briquetting of materials showing high elastic deflection following a discontinued pressure or demonstrating quasi-plastic properties [15]. In the case of raw materials with a high elastic deflection rate reaching 10%, the briquettes that are no longer under pressure have a tendency to get split into halves along the parting plane. In the case of quasi-plastic materials, the ready-made briquettes more easily go out of the moulding cavities and do not block the moulding surfaces. In order to get a wider understanding of the briquetting process in asymmetric systems, the motion of material in the working zone was tested. The experiments were performed with the use of a gravitational feeder, with one of its walls being made of acrylic glass. The consecutive layers of the feed were contrasted by being composed of two materials of

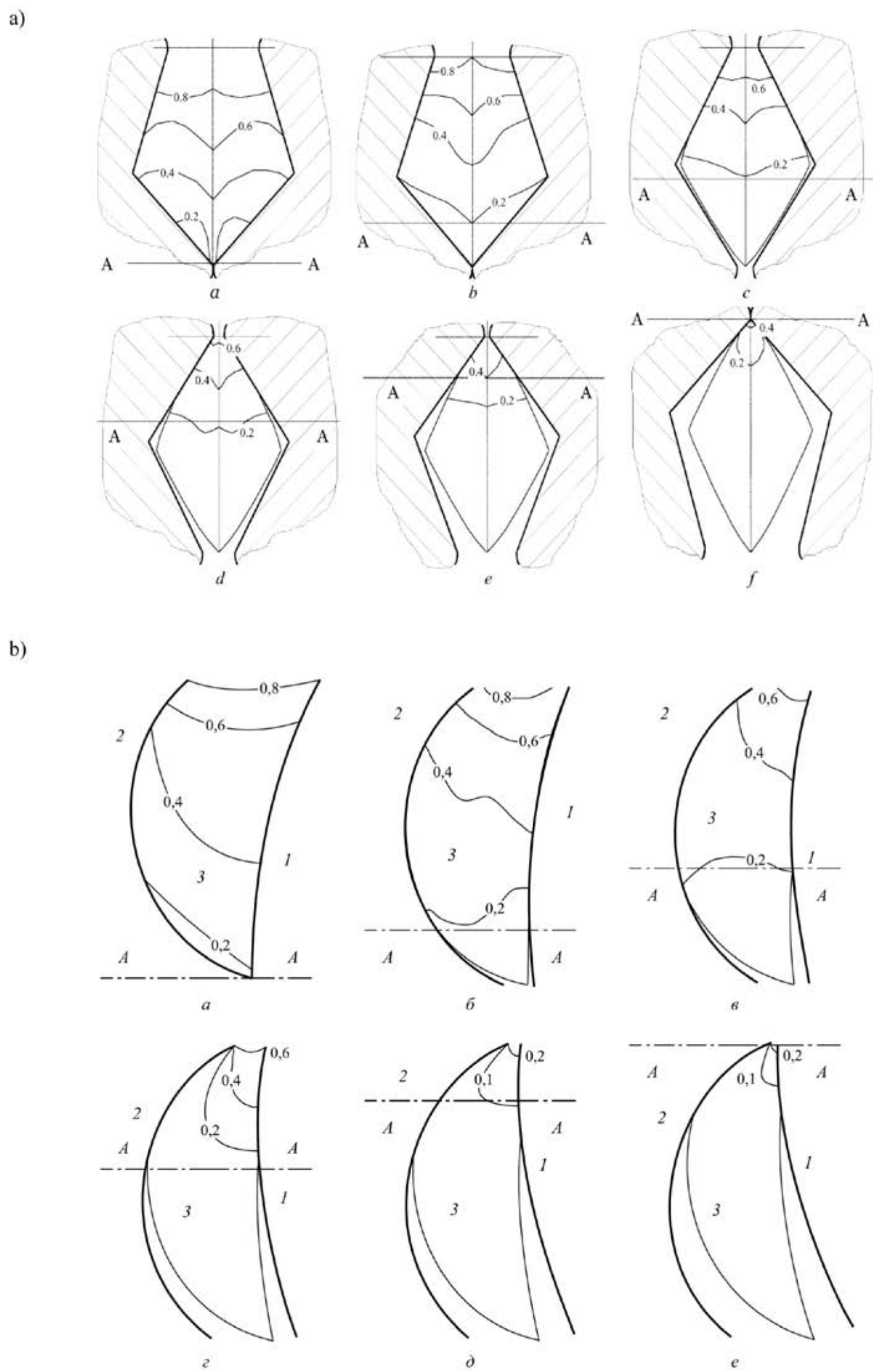

Fig. 3. Distribution of deformations during the briquetting process in a roller press: a) symmetrical compaction unit [23], b) asymmetrical compaction unit [24]

different colours. Copper ore concentrate and calcium hydroxide were used for the tests. The experiments were carried out with different gaps between the rollers, different rotational speeds, and with one or two rollers being driven. The first row of moulding cavities had moulding cavities on the left-side ring, while there was a groove made on the right-side ring, and the second row of cavities was inverted (Fig. 7). The outcome of the analysis of all research has resulted in producing Figure 4, which shows the way in which the material moves in the feeder during the briquetting process in an asymmetrical system. In the first phase of the motion, a layer is formed on the roller working surface with notches, and it adheres to it (the yellow area on Fig. 4a).

It moves with the same rotational speed as the roller, but the feed next to the grooved roller moves at a slower speed. After about 1 second, a layer taken by the second roller also appears next to it, but the thickness of the layer is a little smaller. The flow becomes symmetrical after a few seconds (Fig. 4b). The middle part of the feed (the brown area, Fig. 4) falls down vertically under gravity and additionally exerts pressure on the material in the central part of the compaction unit. When a single roller was driven, the difference that was observed was the smaller thickness of the layer being formed by the profiled roller in the initial motion phase.

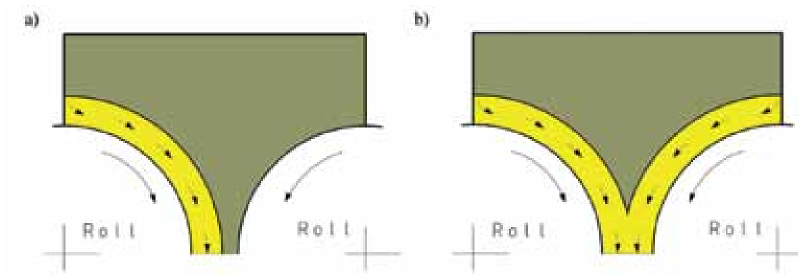

Fig. 4. Scheme illustrating the loose material flow in a gravity feeder during the briquetting process in a roller press asymmetric compaction unit: a) in the initial phase, b) in the final phase

Following the observation of briquetting tests in asymmetrical systems where there is only one row of moulding cavities, it is concluded that the inflow of material in such a system is not symmetrical like at the beginning of the press start-up phase. The symmetricity of the material flow in the further sequence of experiments was caused by an alternate arrangement of notches and grooves in the consecutive rows of cavities. Therefore, it can be concluded that it is not preferable to use moulding rings for briquetting in an asymmetric system where there are only grooves made on one roller and only notches made on the other one (Fig. 5).

Fig. 5. Scheme of an asymmetric compaction unit where the sides of the profile of consecutive rows of cavities is not swapped [27]

The long-lasting operation of asymmetrical saddle-shaped rings has also led to an observation that this kind of moulding surfaces is subject to wear. conventional saddle-shaped cavities, the most intense wear rate affects grooves in places where thresholds separating the moulding cavities of the second ring adhere to the grooves (Fig. 6). This is related to very high pressures exerted in these places and the occurrence of a relative motion of both surfaces that result from the difference in the diameters of the inner part of the groove and the outer part of the notch (Fig. 7). Over the ring life time, the edges of the moulding cavities also become visibly rounded. This is shown on Figure 6.

Fig. 6. Operating wear mechanism of conventional moulding rings used for the production of saddle-shaped briquettes

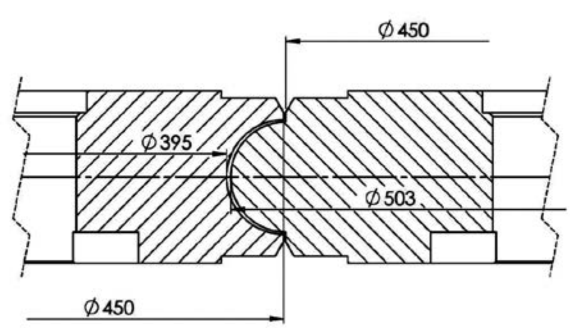

Fig. 7. Cross-section view of a couple of 450 mm diameter moulding rings going through the axes of both rollers

2. Evolution of Asymmetrical Compaction units for Briquetting Machines

The amount of experience gained over several dozen years when roller presses were used for briquetting has proved that there exists a preferable briquette volume related to a specific diameter of moulding rings [15, 20]. This determines the amount of moulding cavities distributed on the perimeter. As the research has shown, there exist two methods to increase the volume of cavities for a given diameter of rollers while maintaining the satisfactory quality of the briquettes. The first of them is to use a screw feeder, and the second consists in increasing the briquette dimension along the generatrix (Fig. 8).

Fig. 8. Saddle-shaped briquette with its volume increased through the extension of one of its sides lying along the moulding ring generatrix

The knowledge which was gained in the course of the laboratory and industry scale research has led to the development of further asymmetric compaction unit concepts which are presented on Figure 9. In this case, there are grooves and notches situated in protrusions that are made along generatrixes on the moulding ring sides. The grooves and notches, which are opposite each other, form a split mould. Apart from the known advantages of the asymmetric system, the rings have been designed so as to enable only one roller to be driven and the torque to be transmitted onto the other roller though friction coupling. This concept was verified in laboratory conditions.

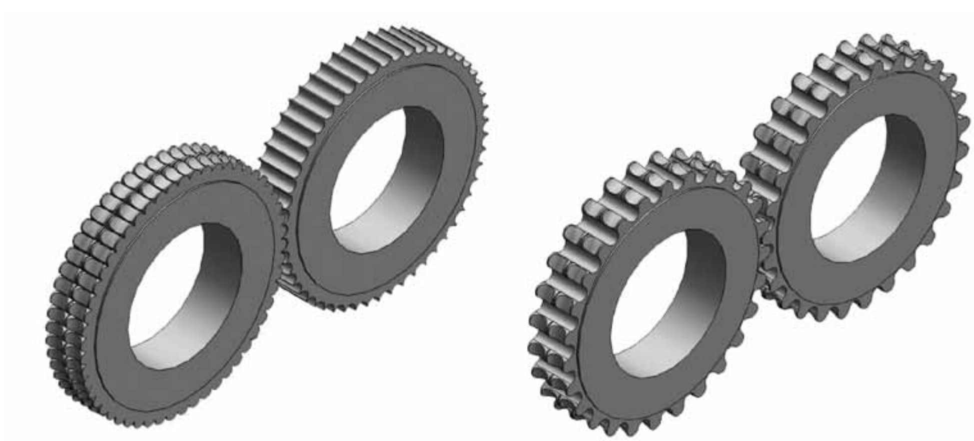

Fig. 9. Scheme of new asymmetrical compaction units: a) subject matter of patent application no P-393053[26], b) subject matter of patent no PL 222229 B1 [25]

The experiments have demonstrated the possibility to obtain durable saddle-shaped briquettes by the application of the a.m. moulding surface solutions. The laboratory research has proved that it is also possible to have one roller driven in conventional saddle-shaped moulding rings (Fig. 6), and that the solution, which is the subject matter of Patent No. PL 222229 B1 (Fig. 9b) is achievable. When only one roller was test-driven, the moulding surface of the rings presented on Figure 9a was destroyed (Fig. 10).

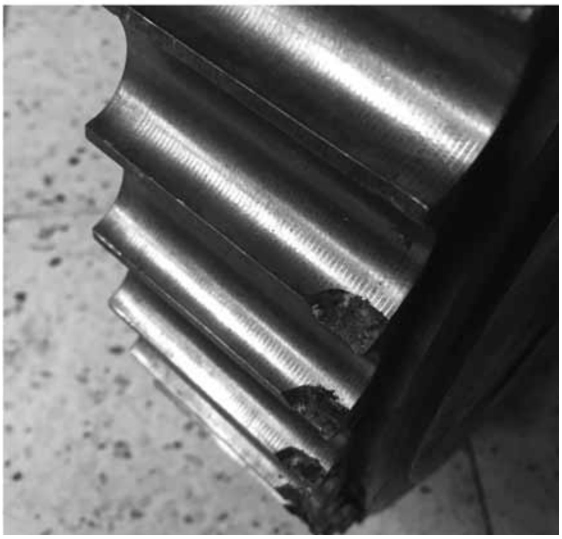

Fig. 10. View of the part of the working surface of the system that is the subject matter of patent application No. P-393053 that has been destroyed as a result of a test drive operation of only one roller of the briquetting machine

Excessive loads caused the peaks of the moulding surfaces on the grooved roller to become destroyed. It therefore follows that the rollers that are the subject of patent application No. P-393053 must both be driven.

3. Summary and Final Conclusions

The use of asymmetrical systems in roller presses has made it possible to expand the portfolio of raw materials which can be consolidated in roller presses. This primarily concerns materials considered to be hardly briquettable in roller presses used mainly in the energy, chemical, pharmaceutical, and heavy industries. Presumably, both the design and the process technology of the asymmetric systems in roller presses will continue to be developed due to their advantages. Probably, the objective will be to design and test new asymmetrical moulding surfaces.

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